(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: **0 203 896**
A2

(12) EUROPEAN PATENT APPLICATION

(21) Application number: **86830137.5**

(22) Date of filing: **23.05.86**

(51) Int. Cl.⁴: **B 04 C 3/06**, B 01 D 45/16

(30) Priority: **27.05.85 IT 4812085**

(43) Date of publication of application: **03.12.86 Bulletin 86/49**

(84) Designated Contracting States: **DE FR GB SE**

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(54) A rising flow separator for a two-phase liquid-gas or liquid-vapour mixture.

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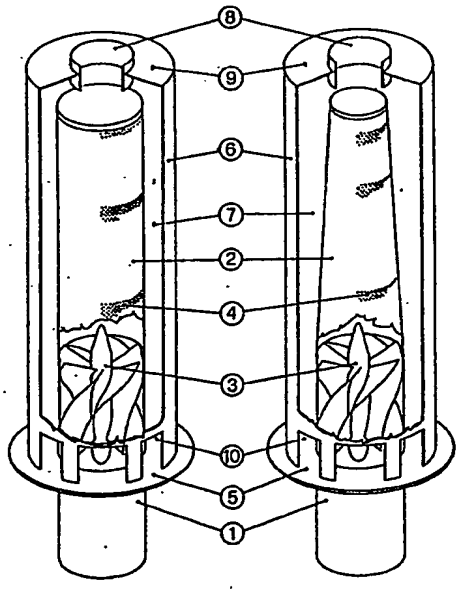

EP 0 203 896 A2

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"A rising flow separator for a two-phase liquid-gas or liquid-vapour mixture."

DISCLOSURE

The present invention relates to an apparatus for the separation of the components or phases of a liquid-gas or liquid-vapour mixture in rising motion which uses the effects of centrifugal force to separate said two components or phases having a different density.

Apparatus of the above mentioned kind are known and find a specific use in conventional or nuclear-powered steam generators for the separation of the two-phase mixture steam-water and are located in the interior of the generators themselves in an environment which is filled, up to a given level, with the liquid phase.

In such apparatus the separation of the phases of a liquid-gas of liquid-vapour mixture is effected by centrifugation promoted by a suitably shaped stationary blading located in the path of the rising flow of said mixture. As a consequence of said centrifugation a vortex is created constituted by a nucleus of the lighter phase, i.e. the gas, surrounded by a thin layer or film of the heavier phase, i.e. the liquid. The above mentioned vortex is contained into a separation chamber which is generally provided with a top axial outlet for the lighter phase and either one or several radial outlets for the heavy phase. Whereas the separated light phase flows through said top axial outlet, a chamber concentrical

and external with respect to said separation chamber collects the separated heavy phase, and owing to the effect of the force of gravity, conveys it downwards where it is discharged through discharge outlets.

The abovementioned known apparatus have the drawback in that they show acceptable performances only within a limited range of operative conditions; this in particular with regard to the rate of the two phases entering into the separator and the immersion depth of the collection chamber, which originates a hydraulic head acting on the delivery outlets for the separated liquid phase. An appreciable dependency of the performance upon the instantaneous fluctuations of the single flow rates also exists, caused by the kind of motion of the two phase mixture which is set up in the inflow conduit upstream of the separator.

The aim of the present invention is to overcome the abovementioned inconveniences, of the conventional similar devices or at least to minimise said inconveniences, by providing an apparatus wherein both the phases constituting the mixture are made to come out at different levels through outlets anyhow distributed along the peripheral wall of the separation chamber closed at the top eliminating for the gaseous phase the possibility of a direct exit through the top axial opening in said chamber adopted up to now in the known separators.

Thanks to the aforesaid artifice, the lowermost located outlets in the peripheral wall of the separation chamber are committed to the discharge of the liquid phase which constitutes the external envelope of said vortex while those at the top are committed to the discharge of the gaseous phase.

However, there is no net boundary between the outlets destined to the discharge of the liquid phase and those destined to the discharge of the gaseous phase. As a matter of fact the distribution between the former and the latter is automatically established with relationship to the operating conditions of the apparatus (flow rates of the single phases, hydraulic heads on the outflow outlets for the liquid).

The variation of one of the above mentioned parameters causes a change of pressure in the separation chamber; a negative feedback is set up, which for an increase in gas pressure causes an increase in the delivery outlets at the disposal of the gaseous phase. This favours, besides the stabilization of the operation of the apparatus, the achievement of higher performance, such as, for instance, an appreciable separation capability of the phases or components of the mixture within wide limits. The motion of the two-phase mixture at the inlet of the apparatus is on average a stationary one, but generally characterised by oscillation of the instantaneous flow rates of the two phases.

The performance of the apparatus of the invention is good in a range of operating conditions which is appreciably wider than that of the known similar apparatus.

Differently from the conventional apparatus, wherein the discharge of the phases occurs through fixed and distinct outlets, in the invention the quantity of outlets utilized for the outflow of the separated phases is variable as a function of the operating conditions.

The geometry adopted for the separation chamber and the mode of extracting the two phases from it according to the present invention reduce moreover the possibility

of stagnation points for the liquid phase which constitute the source of possible re-mixing of the two separated phases because in the separation chamber the motion is directed upwards.

The separated liquid and gaseous phases, outflowing from the separation chamber, arrive into an annular external chamber which surrounds coaxially the separation chamber and which is provided at its top with an orifice for the discharge to the exterior of the gaseous phase, and at the bottom with a series of peripheral apertures for the discharge of the liquid phase.

Experimental laboratory tests, performed on exemplary prototypes of small and large scale in a wide range of experimental situations, have evidenced a surprisingly high capability of separating the phases or components of the process mixture within wide limits.

The present invention will be better disclosed hereinafter from the description of preferred embodiments, given as a non limiting example, with reference to the attached drawings, wherein:

figure 1 is an isometric view, with missing parts, of a first embodiment of the apparatus in question;

figure 2 is an isometric view similar to figure 1 of a second embodiment of the apparatus in question; and

figures 3a) and b) are sectional views and elevation views, repectively, of a third embodiment of the apparatus in question.

Passing to study figures 1 and 2 wherein a first and a second substantially similar embodiment of the present invention are shown and in which the same components are indicated with the same reference numbers, number 1 indicates the inlet pipe which conveys with a rising motion

the two-phase mixture to be divided into single phases into the separation chamber 2 comprising a tubular body with a closed top end having a cylindrical shape in the embodiment of figure 1 and a substantially frusto-conical shape in the embodiment of figure 2.

In the interior of the bottom portion of the separation chamber 2 a vortex generator 3 is installed comprising a suitable fixed blading shaped in order to impose on the rising two-phase mixture an helical motion such as to create a field of centrifugal force suitable for separating the two phases of said mixture having a different density, as will be better explained hereinafter.

Over the vortex generator 3 are machined into the peripheral wall of the separation chamber 2 a plurality of outlets 4 uniformly distributed for the outflow at different levels of the separated phases of said mixture.

At the exterior of the separation chamber 2, in a spaced and coaxial relationship is mounted on a supporting annular plate 5, integral with the lower end of the separation chamber 2, a cylindrical tubular wall 6 suitable for constituting a collection chamber 7 for each separated phase, to convey them to the respective outlet ports constituted, for the gaseous phase, by an orifice 8 shaped in a central position in the cover 9 of chamber 7, and for the liquid phase, by several openings 10 machined in an equally spaced manner circumferentially at the base of wall 6.

As may be derived from the above and from a study of figures 1 and 2, the sole difference existing between the first and the second embodiment of the apparatus according to the present invention consists in the shape of the separation chamber 2, which is cylindrical in the

first embodiment and substantially frusto-conical in the second embodiment.

The reasons which have led to the adoption of the substantially frusto-conical shape of the separation chamber 2 of figure 2 are due to the ability to obtain a greater spacing between the wall of said chamber and the external wall 6 in order to allow a greater passage area in the annular chamber 7 so as to reduce the outflow velocity of the two phases thus limiting both the possibility of entrainment of liquid by the gas or vapour, and the possibility of entrainment of gas or vapour by the liquid.

With reference now to figures 3a) and b) wherein a third embodiment of the apparatus of the present invention is shown, and wherein the same elements already described with reference to the previous embodiments are indicated with the same reference numbers shown in figures 1 and 2 and without a further disclosure, one may see that the separation chamber comprises a lower part 11 constituted by a cylindrical tubular body wherein the vortex generator 3 is located, and a distinct and separated upper part 12 constituted by a frusto-conical tubular body on the peripheral wall of which are machined a plurality of outflow ports 4 for the separated phases of the mixture being processed, said upper part 12 being surrounded in a spaced and coaxial relationship by the cylindrical tubular wall 6 mounted on the annular supporting plate 5 to create, as abovementioned, a collection chamber 7 for the separated phases of the mixture and to convey them to the respective discharge outlets constituted, as in the previous instances, by an orifice 8 in the cover 9 of of the chamber 7 and by several peripheral openings 10 at the bottom of the wall 6.

In the present embodiment the upper part 12 of the separation chamber is provided circumferentially and at the top with a number of ports 13 having dimensions substantially greater than those of the openings 4 in order to promote the outflow of the gaseous phase near the discharge orifice 8 while at its lower end a film-scraper device, generally shown as 14, is provided to promote the outflow of the liquid phase near the discharge openings 10, said device comprising an annular member 15, peripherally fastened at the exterior of the lower end portion of the upper part 12 of the separation chamber, integral with a short shell 16 which extends downwards.

For the assembly of the two separate parts of the separation chamber, the top terminal portion of the lower part 11 is fastened to the central opening of the annular plate 5 so as to protrude for a short distance above the latter in a spaced relationship with respect to the film-scraper device 14 while the upper part 12 is fastened to the lower part 11 by means of an adequate number of welding spots which unite the portion of the latter that protrudes under plate 5 to shell 16 of the film-scraper device 14.

In the operation of the apparatus of the present invention, in the embodiments disclosed with reference to figures 1 and 2, a two-phase mixture is conveued through the in-flow pipe 1 to the separator in question. In passing through the vortex generator 3, the mixture acquires a helical motion and due to the effects of the centrifugal force field thus set up, the separation of the two phases having a different density occurs, with the formation of a nucleus constituted by the lighter gaseous phase surrounded by a film constituted by the heavier

liquid phase. The liquid phase then contacts the internal wall of the separation chamber 2 and is gradually expelled into the collection chamber 7 through the openings 4 located at a lower height while the gaseous phase continuing in its rising motion is also expelled into the collection chamber 7 through the openings 4 located at a greater height.

In passing through the openings 4 the rotational motion of the two separated phases is substantially reduced so that in the collection chamber 7 the liquid phase flows downwards by gravity arriving at the outlet ports 10 which put it into communication with the exterior while the gaseous phase flows upwards until coming out through the discharge orifice 8.

The dimensions of both the orifice 8 and the openings 10 should be conveniently selected with reference to the operating conditions so that in the collection chamber 7 an hydrostatic head sufficient to prevent the exit of the separated gaseous phase through the discharge outlets for the liquid is always present.

The subdivision between the openings 4 of the separation chamber 2 committed to the outflow of the liquid phase and those committed to the outflow of the gaseous phase depends, as abovementioned, upon the operating conditions (flow rate of the two phases, hydrostatic heads) which also influence the pressure conditions set up in the interior of the separation chamber 2 owing to head losses caused by the outflow openings 4. Said pressure, by means of its variations, limits the variations in the subdivision of the respective openings 4 of the separation chamber 2 committed to the outflow of the two phases.

The possibility of pressure changes in the interior of the latter, causes a negative feedback effect with a stabilizing action; a wide range of operating conditions results therefrom, in which the performances of the separator are appreciably higher.

Insofar as the operation of the apparatus according to the invention in the embodiment described with reference to figure 3 is concerned, it should be remarked that it is performed substantially in the manner previously disclosed with the exception that: normally a prevailing part of the liquid phase outflows from the separation chamber through the passage between the upper end part of the lower part 11 of said separation chamber and the shell 16 of the film-scraper device 14, when the liquid film that surrounds the gaseous core in said vortex formed in passing through the vortex generator 3 impinges in the helical rising motion against the peripheral lower surface of the annular member 15 of said device; the gaseous phase is discharged from the upper part 12 of the separation chamber into the collection chamber mainly at the top through the openings 13 near the orifice 8 for the outflow to the exterior.

These arrangements allow the limiting of the speed within the interior of the separation chamber and the collection chamber even with reduced radial dimensions.

The present invention is not limited to the disclosed embodiment example, but encompasses any change or modifications of the same.

CLAIMS

1. A rising flow separator for a two-phase liquid-gas or liquid-vapour mixture, comprising: a tubular chamber for the separation of the phases of said mixture; a vortex generator device located in correspondence with the inlet of said separation chamber; a collecting chamber external and coaxial with respect to said separation chamber; said separator being characterized in that said separation chamber is provided with a top closure cover and in that in the peripheral wall of said separation chamber a plurality of openings is provided for the outflow at different levels of the separated phases of said mixture and that said collection chamber is provided at the top with an orifice for the discharge of the separated gaseous phase and at the bottom with at least one aperture for the discharge of the separated liquid phase, the subdivision of said openings committed to the outflow of the separated gaseous phase and those committed to the separated liquid phase being dependent upon the operating conditions which also affect the pressure in the interior of said separation chamber so as to produce a counterpressure apt to allow the damping of the fluctuations of said two phases.

2. A separator according to claim 1, wherein said separation chamber is constituted by a tubular cylindrical body with the top end closed.

3. A separator according to claim 1, wherein said separation chamber is constituted by a frusto-conical tubular body with the top end closed.

4. A separator according to claims 1 to 3 wherein said vortex generator device is constituted by a fixed blading.

5. A separator according to any of the preceding claims

wherein said discharge orifice of the gaseous phase separated in said collection chamber is obtained at the center of the cover wall of said collection chamber.

6. A separator according to any of the preceding claims wherein at the bottom of said collection chamber a number of openings are provided, being peripherally arranged for the discharge of said separated liquid phase.

7. A separator according to any of the preceding claims wherein said separation chamber is provided at its top with a series of peripherally arranged openings to facilitate the outflow of said separated gaseous phase, in particular near said discharge orifice in said collection chamber.

8. A separator according to any of the preceding claims wherein downstream of said vortex generator device a film-scraper device is provided to facilitate the outflow of said separated liquid phase through an annular opening in said separation chamber, in particular near at least one of the discharge openings in said collection chamber.

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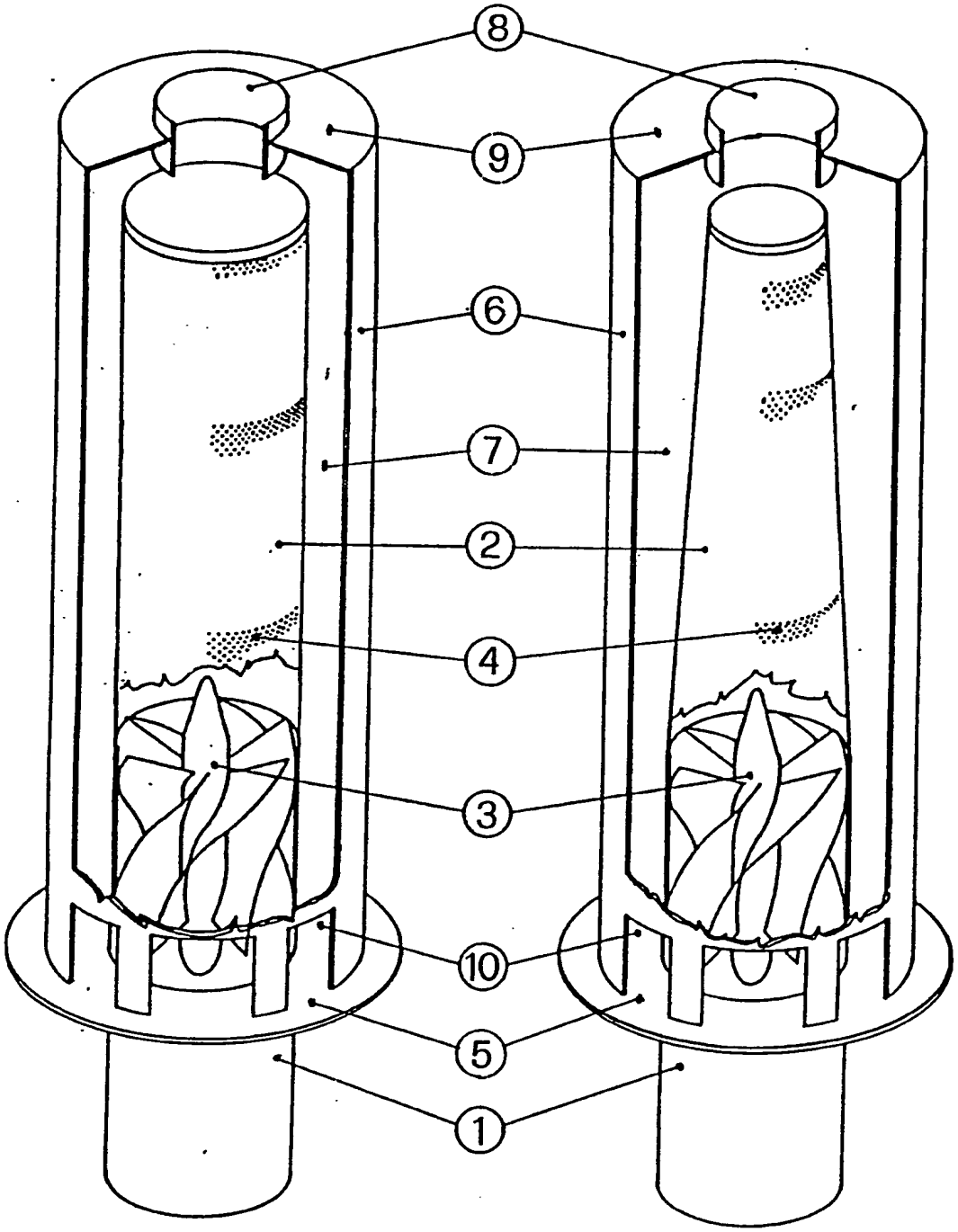
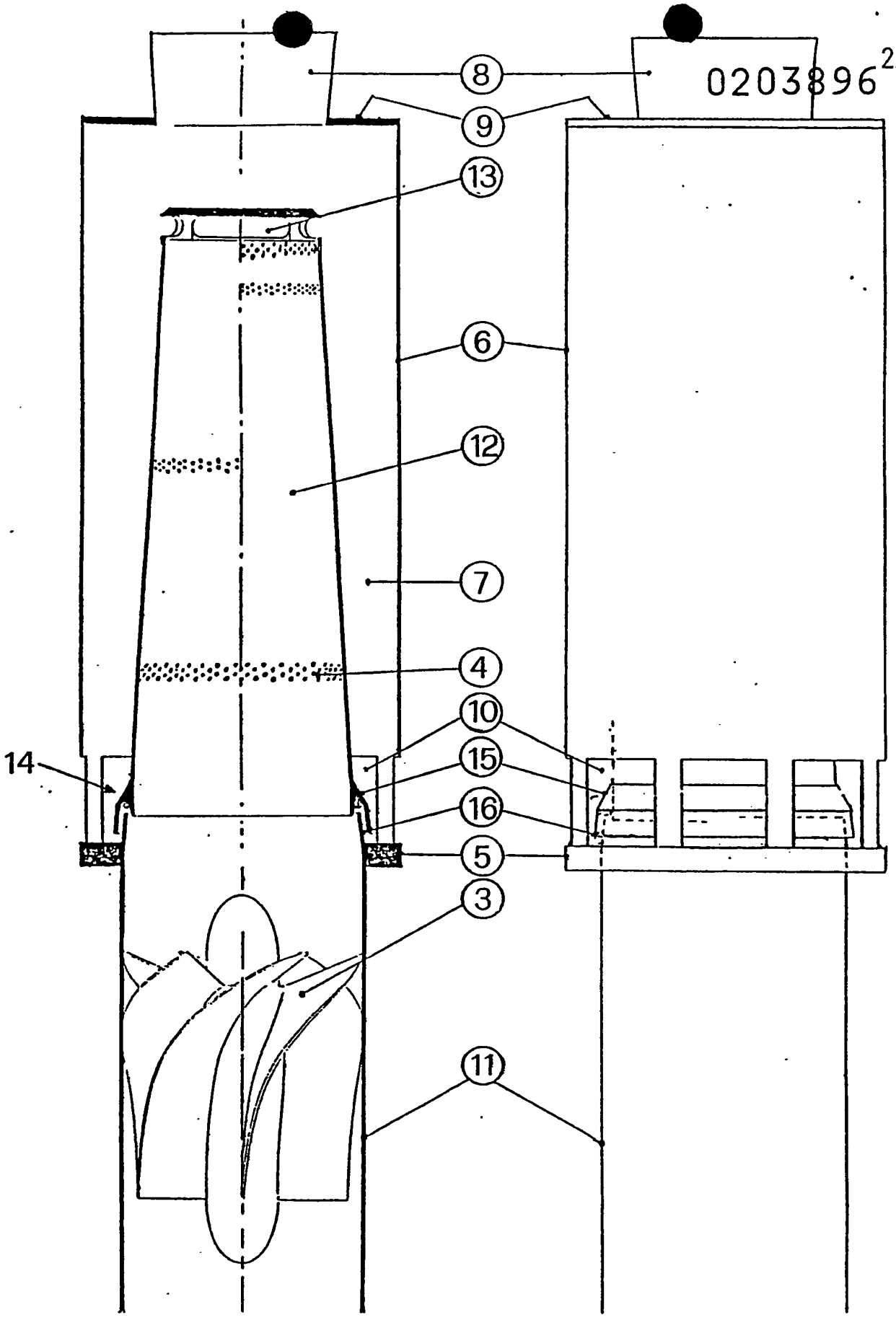


FIG.1

FIG.2



a) FIG. 3 b)

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(11) Publication number: **0 203 896**
A3

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(22) Date of filing: 23.05.86

(51) Int. Cl.⁴: B 04 C 3/06
B 01 D 45/16

(30) Priority: 27.05.85 IT 4812085

(43) Date of publication of application:
03.12.86 Bulletin 86/49

(88) Date of deferred publication of search report: 13.05.87

(84) Designated Contracting States:
DE FR GB SE

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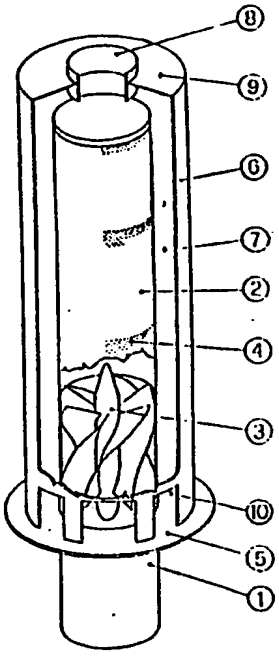

FIG.1

EP 0 203 896 A3

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EUROPEAN SEARCH REPORT

Application number: 0203896

EP 86 83 0137

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
A	FR-A-1 213 496 (C.E.A.) * Page 1, right-hand column, line 9, page 2, left-hand column, line 20; figures 1,4 *	1-4,7	B 04 C 3/06 B 01 D 45/16
A	WO-A-8 101 110 (MALONEY-CRAWFORD CORP.) * Page 2, line 17 - page 4, line 5; page 4, line 24 - page 5, line 7; figures 1,2 *	1-7	
A	EP-A-0 055 413 (TECHNIQUES LUMMUS) * Page 2, lines 16-33; figure 2 *	1,2,4-6	
A	US-A-3 651 619 (MITSUGI MIURA) * Column 2, line 49 - column 3, line 4; column 3, line 47 - column 4, line 14; figures 1-3 *	1-3	TECHNICAL FIELDS SEARCHED (Int. Cl.4) B 04 C B 01 D F 22 B G 21 C
A	FR-A-2 239 275 (BAYER) * Page 1, line 27 - page 2, line 9; page 3, line 32 - page 4, line 11; figure *	8	
A	FR-A-2 027 434 (COMBUSTION ENGINEERING)		

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	09-02-1987	LAVAL J.C.A

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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